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# How To Evaluate Longwall Dust Sources With Gravimetric Personal Samplers

By Steven J. Page, Robert A. Jankowski,  
and Fred N. Kissell



UNITED STATES DEPARTMENT OF THE INTERIOR



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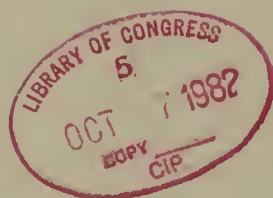


**UNITED STATES DEPARTMENT OF THE INTERIOR**

James G. Watt, Secretary

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# HOW TO EVALUATE LONGWALL DUST SOURCES WITH GRAVIMETRIC PERSONAL SAMPLERS

By Steven J. Page,<sup>1</sup> Robert A. Jankowski,<sup>2</sup>  
and Fred N. Kissell<sup>3</sup>

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## ABSTRACT

Longwall double-drum shearers frequently have difficulty complying with the 2.0 mg/m<sup>3</sup> dust standard and, therefore, require the use of effective dust controls. However, before dust controls can be implemented effectively, the major individual dust sources must be determined and their relative severity evaluated.

The Bureau of Mines has recently developed a sampling strategy, based upon short-term gravimetric sampling, that can identify the major dust sources contributing to the shearer operator's exposure. This technique utilizes approved gravimetric sampling equipment already available to all mine operators and can be performed by two people in 2 days. Five examples, including data analysis, are discussed with respect to various cutting sequences.

In addition, typical dust source contributions obtained from studies of double-drum shearer operations regularly in compliance are included. Mine operators can thereby compare their dust source evaluation results with those from these longwalls.

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## INTRODUCTION

The objective of this report is to provide to the mine operator a sampling strategy for evaluating longwall dust sources and the range within which the dust concentrations for these sources should lie. This is important because major dust sources must be identified before dust controls can be recommended and applied correctly. The shearer operator is typically a high-risk occupation; for this reason the sampling strategy presented is aimed at the shearer operator's exposure to the major dust sources.

The standard method of evaluating dust exposure is by collecting personal samples over an 8-hr period. Although this

method is the most appropriate estimate of a worker's full-shift exposure, it is far from adequate for identifying dust sources and their severity or for evaluating the effectiveness of dust control techniques. The Bureau has recently developed an uncomplicated sampling strategy, based upon short-term gravimetric sampling, that works effectively. This technique utilizes approved gravimetric sampling equipment already available to all mine operators. The objective is not to precisely define the dust source contributions, but to allow the mine operator to determine *sufficiently* where dust problems are in the shortest and simplest way.

## SAMPLING METHOD

Evaluating longwall dust sources requires that two kinds of dust samples be taken: (1) stationary and (2) mobile. It is necessary for both kinds that a minimum of four personal samplers be used. Multiple samplers arranged in a package are necessary to insure accuracy and to obtain a valid average measurement of the respirable dust concentration because sampling is done for short periods of time (typically 20 to 30 min).<sup>4</sup>

For stationary samples, figure 1 shows two recommended methods, as it is

important to keep the cyclone samplers within a 12-inch radius.

For mobile samples, two techniques are available. Either a package can be hand-carried, as shown in figure 1, or the sampler vest, shown in figure 2, can be used. The sampler vest is simply a fishing vest that contains four large pockets suitable for holding the sampling pumps; the four cyclone samples are located on the right and left lapels of the vest. This particular arrangement gives the wearer hand freedom to make other measurements, such as airflow.

## SAMPLING STRATEGY

It is important to note that the sampling strategy is based upon the fact that the dust concentration measured at any location is a composite of all dust sources upstream of that location. The

sampling locations, designated in figure 3, are the same, regardless of cutting sequence; they allow the mine operator to determine the shearer operator's exposure to the major dust sources:

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<sup>4</sup>In general, all four of the measured dust concentrations in each package should be used for determining the average concentration. However, you should use your own judgment in omitting one of the values from the calculation if (1) one of the values is substantially different or (2) a sampler was known not to be functioning properly during the test.

- A--section intake
- B--15 ft on shearer intake, tail-to-head
- C--midpoint of shearer, tail-to-head
- D--15 ft on shearer intake, head-to-tail
- E--midpoint of shearer, head-to-tail.

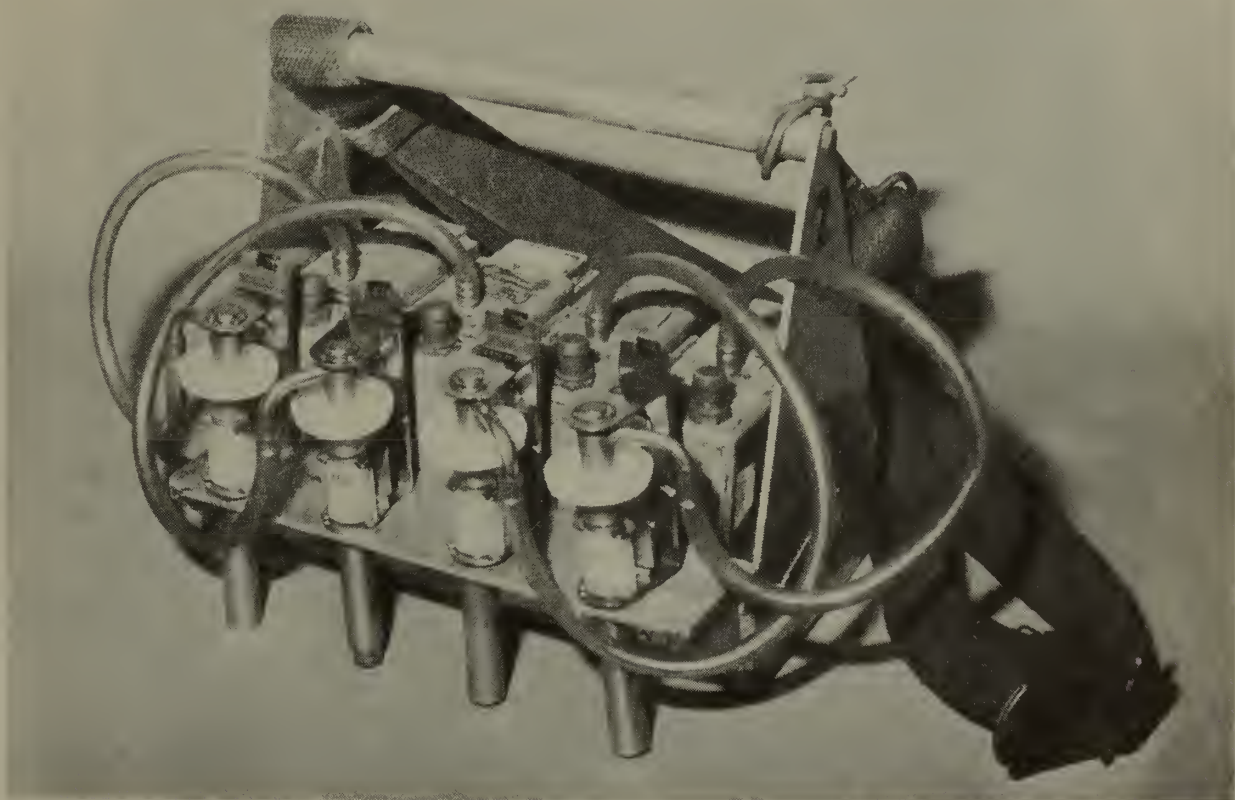
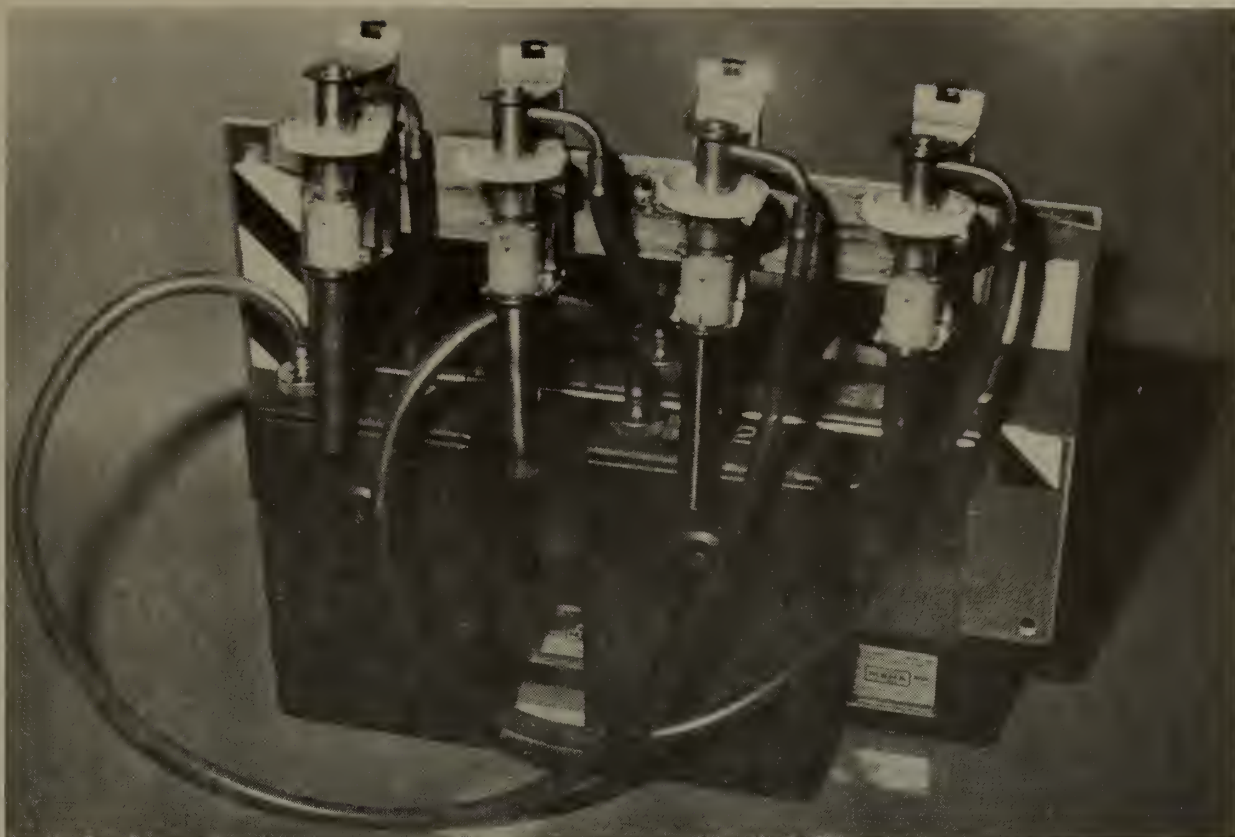


FIGURE 1. - Hand-held sampler packages.



FIGURE 2. - Sampler vest.

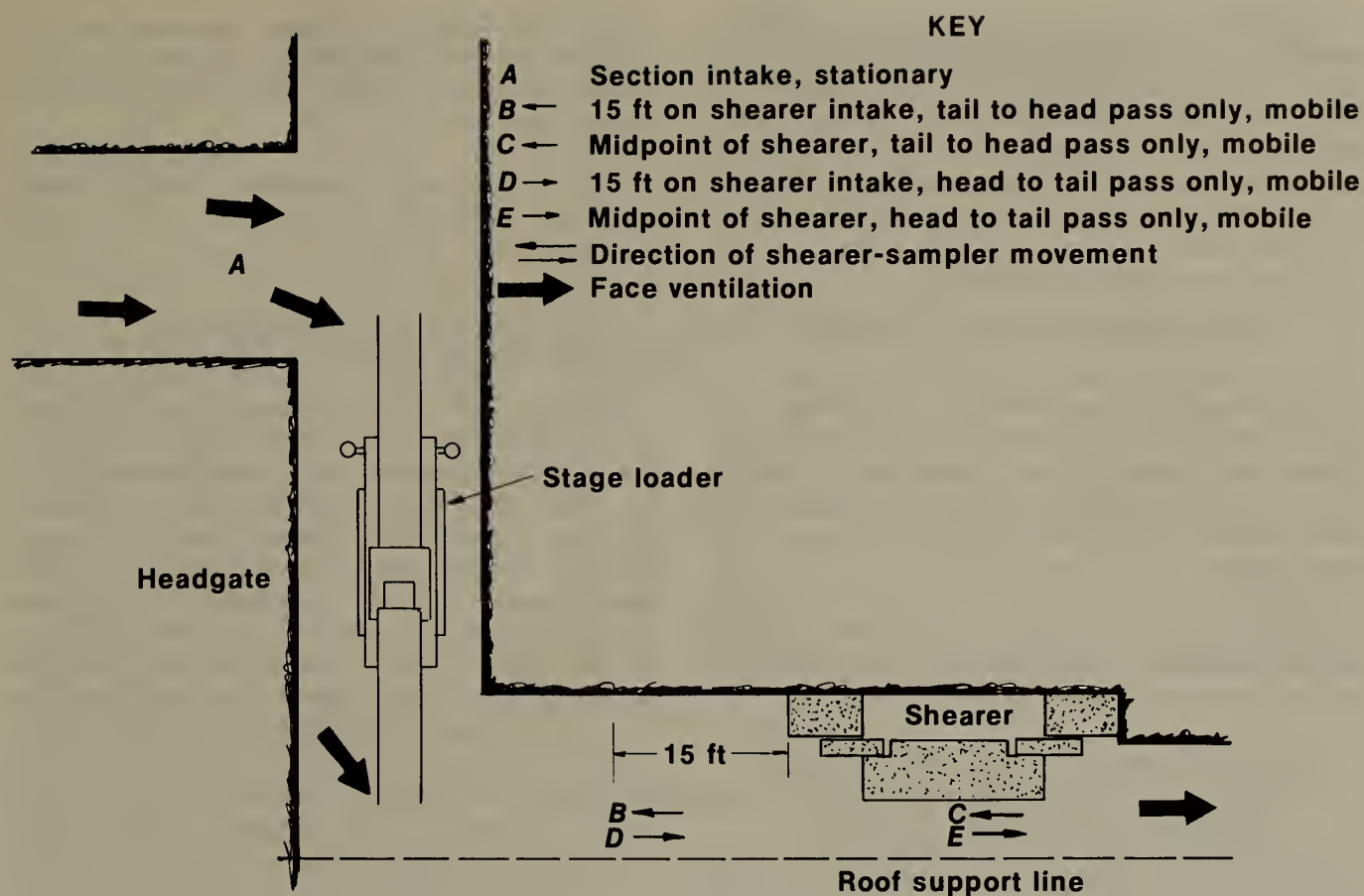


FIGURE 3. - Sampling location designations.

The sampling strategy is carried out by a survey team consisting of two individuals, with each collecting the mobile gravimetric samples during selected segments of the mining cycle. The sampling is divided into two main phases:

1. A set of samples collected on the head-to-tail pass.<sup>5</sup>
2. A different set of samples collected on the tail-to-head pass.

*One individual stands at the midpoint of the shearer, and the other stands approximately 15 to 20 ft on the intake air side of the shearer. In addition, there is a stationary sampler package, located in the last open crosscut, to measure the section's intake dust concentration. Appendix A provides a step-by-step sampling sequence as an example.*

#### CALCULATION EXAMPLES OF MINE DATA

In the following examples, the sampling locations are those designated in figure 3. At the top of each table presented are the sampling locations and sampling times, as well as the dust concentrations obtained at each location.

The dust concentration and sampling times at the various locations are *average* values for *all* passes. These average values are then treated as if they were obtained on one single pass. In the lower portion of the table are listed the dust sources and the calculation of their contributions. For example, the section intake contribution is

<sup>5</sup>A pass is defined as movement from *either* head-to-tail or tail-to-head.

simply the value of A; the stage loader-conveyor contribution is obtained by subtracting A from B and is designated (B-A), and so forth for the other dust sources. The time fraction of the mining cycle is simply the percentage of the total sampling time for both passes that a given dust source contributes to the shearer operator's exposure.

For all examples, the ventilation intake is at the headgate, and there are no atypical operations that affect the sampling results.

The average source contribution (tables 1-5) is obtained from the equation

$$\text{avg source contribution (mg/m}^3\text{)} = \text{dust source concentration (mg/m}^3\text{)} \\ \times \text{time fraction of mining cycle (pct).}$$

Appendix B is provided to allow the mine operator to compare the provided examples, as well as sampling results from the mine, with the shearer operator dust source contributions for shearers in compliance.

Appendix C provides information on filter weight requirements and sampling error considerations.

Mine 1--Unidirectional Head-to-Tail  
Cutting Sequence With Support  
Movement on Shearer Intake

Mine 1 has roof support movement on the intake air side of the shearer during the head-to-tail cut.

Results of the sampling analysis are shown in table 1. According to table 1, the section intake (A) contributes 1 pct to the total source contribution 100 pct of the time; the stage loader-conveyor (B-A), operating 100 pct of the time, contributes 23 pct to the total; roof support movement (D-B),<sup>6</sup> operating 67 pct of the time, contributes 11 pct to the total; the head-to-tail shearer cut (E-D), operating 67 pct of the time, contributes 62 pct to the total; and the tail-to-head shearer cleanup (C-B), operating 33 pct of the time, contributes 3 pct to the total.

TABLE 1. - Dust source data for mine 1

Sampling location <sup>1</sup> .....	A	B (cleanup)	C (cleanup)	D (cut)	E (cut)
Sampling time.....min..	42	14	14	28	28
Dust concentration..mg/m <sup>3</sup> ..	0.1	1.8	2.3	3.0	9.9
Dust source.....	A	B-A	D-B	E-D	C-B
Description.....	Section intake.	Stage loader-conveyor.	Support movement.	Shearer (cut).	Shearer (cleanup).
Dust source concentration mg/m <sup>3</sup> ..	0.1	1.7	1.2	6.9	0.5
Time fraction of mining cycle.....pct..	100	100	67	67	33
Average source contribution mg/m <sup>3</sup> ..	0.1	1.7	0.8	4.6	0.2
Percent of total source contribution <sup>2</sup> .....	1	23	11	62	3

<sup>1</sup>See figure 3.

<sup>2</sup>Total source contribution, 7.4 mg/m<sup>3</sup>; this represents average exposure during cutting and not exposure for compliance purposes.

<sup>6</sup>Calculation of the roof support movement contribution (D-B) is based on the assumption that the stage loader-conveyor contribution is the same on both cleanup and cutting. Table 4 indicates that there is no significant difference, although this may not always be true.

This mine was regularly out of compliance. The short-term sampling has identified two problem areas: (1) the head-to-tail cut (62 pct); and (2) the stage loader-conveyor (23 pct). Referring to table B-1 (appendix B), both of these values lie outside the ranges for the cleanest longwalls. Efforts can now be concentrated on these two areas to achieve compliance. For this operation, the shearer cut the full seam on the head-to-tail pass. The effect of this cutting sequence placed the trailing headgate drum (which is cutting bottom coal) on the intake air side of the shearer. A logical corrective measure would be to employ a modified unidirectional head-to-tail cutting sequence<sup>7</sup> where the bottom coal is cut on the tail-to-head cleanup by the tailgate drum. This has the effect of putting the bottom cut on the return air side of the shearer rather than on the intake air side.

Mine 2--Unidirectional Tail-To-Head  
Cutting Sequence With Support  
Movement on Shearer Intake

Mine 2 has roof support movement on the intake air side of the shearer during the head-to-tail cleanup pass.

Results of the sampling analysis are shown in table 2. According to table 2, the section intake (A) contributes 13 pct to the total source contribution 100 pct of the time; the stage loader-conveyor (B-A), operating 100 pct of the time, contributes 7 pct to the total; roof support movement (D-B), operating 36 pct of the time, contributes 7 pct to the total; the tail-to-head shearer cut (C-B), operating 64 pct of the time, contributes 20 pct to the total; and the head-to-tail shearer cleanup (E-D), operating 36 pct of the time, contributes 54 pct to the total.

TABLE 2. - Dust source data for Mine 2

Sampling location <sup>1</sup> .....	A	B (cut)	C (cut)	D (cleanup)	E (cleanup)
Sampling time.....min..	55	35	35	20	20
Dust concentration...mg/m <sup>3</sup> ..	0.6	0.9	2.3	1.6	8.5
Dust source.....	A	B-A	D-B	C-B	E-D
Description.....	Section intake.	Stage loader-conveyor.	Support movement.	Shearer (cut).	Shearer (cleanup).
Dust source concentration mg/m <sup>3</sup> ..	0.6	0.3	0.7	1.4	6.9
Time fraction of mining cycle.....pct..	100	100	36	64	36
Average source contribution mg/m <sup>3</sup> ..	0.6	0.3	0.3	0.9	2.5
Percent of total source contribution <sup>2</sup> .....	13	7	7	20	54

<sup>1</sup>See figure 3.

<sup>2</sup>Total source contribution, 4.6 mg/m<sup>3</sup>; this represents average exposure during cutting and not exposure for compliance purposes.

<sup>7</sup>U.S. Bureau of Mines. Modified Cutting Sequence Reduces Longwall Shearer Operators' Dust Exposure. Technol. News, No. 116, 1981.

This mine was regularly in compliance. However, notice that the head-to-tail cleanup, which was only a third of the mining cycle, contributed more than one-half of the shearer operator's dust exposure. The reason for this is that, on the cleanup pass, the headgate drum was cutting bottom rock on the intake air side of the shearer. It is well known that cutting rock creates a much larger amount of dust. Similar to that for mine 1, a corrective measure would be to use a modified unidirectional tail-to-head cut where the entire seam is cut on the tail-to-head pass. This would place the bottom cut (rock grinding) on the return air side of the shearer.

#### Mine 3--Bidirectional Cutting Sequence

Mine 3 has roof support movement on the return air side of the shearer during the

tail-to-head cut and on the intake air side of the shearer during the head-to-tail cut.

Results of the sampling analysis are shown in table 3. According to table 3, the section intake (A) contributes 43 pct to the total source contribution 100 pct of the time; the stage loader-conveyor (B-A), operating 100 pct of the time, contributes 19 pct to the total; the roof support movement (D-B), operating 55 pct of the time, contributes 7 pct to the total; the tail-to-head shearer cut (C-B), operating 45 pct of the time, contributes 31 pct to the total; and the head-to-tail shearer cut (E-D), operating 55 pct of the time, contributes 0 pct to the total.

TABLE 3. - Dust source data for Mine 3

Sampling location <sup>1</sup> .....	A	B (cut)	C (cut)	D (cut)	E (cut)
Sampling time.....min..	47	21	21	26	26
Dust concentration.....mg/m <sup>3</sup> ..	1.8	2.6	5.5	3.2	3.1
Dust source.....	A	B-A	D-B	C-B	E-D
Description.....	Section intake.	Stage loader-conveyor.	Support movement.	Shearer (cut).	Shearer (cut).
Dust source concentration mg/m <sup>3</sup> ..	1.8	0.8	0.6	2.9	20.0
Time fraction of mining cycle pct..	100	100	55	45	55
Average source contribution mg/m <sup>3</sup> ..	1.8	0.8	0.3	1.3	0
Percent of total source contribution <sup>3</sup> .....	43	19	7	31	0

<sup>1</sup>See figure 3.

<sup>2</sup>Quantity (E-D) is actually negative: see section "Mine 3" and Appendix C for explanation.

<sup>3</sup>Total source contribution, 4.2 mg/m<sup>3</sup>; this represents average exposure during cutting and not exposure for compliance purposes.

Notice that, although roof support movement occurs on both passes, that is, 100 pct of the time, only 55 pct of the time is attributed to it. The reason for this is that the shearer operators are exposed to roof support dust only on the head-to-tail cut. The roof supports are moved on the return air side of the shearer during the tail-to-head cut, and, thus, do not contribute.

Another apparently strange result is the 0-pct contribution (see appendix C) of the shearer on the head-to-tail cut. Inspection of the quantity (E-D) shows that it is actually slightly negative. This says that since the sample 15 ft on the shearer intake air side is slightly greater than the value at the shearer midpoint, the dust at the shearer midpoint is essentially a combination of

only coal transport dust and roof support movement dust. This physically makes sense because on the head-to-tail pass, the tailgate drum is cutting most of the coal (and making the most dust) and is on the return air side of the shearer. The headgate drum is on the shearer intake air side but is cutting very little coal and, therefore, making very little dust.

This mine was regularly out of compliance. Inspection of the results shows where the problem area is: the section intake (43 pct).

Mine 4--Unidirectional Tail-to-Head  
Cutting Sequence With Support  
Movement on Shearer Return

Mine 4 has roof support movement on the return air side of the

shearer during the tail-to-head cut pass.

Results of the sampling analysis are shown in table 4. According to table 4, the section intake (A) contributes 15 pct to the total source contribution 100 pct of the time; the stage loader-conveyor on the cut pass (B-A), operating 71 pct of the time, contributes 10 pct to the total; the stage loader-conveyor on the cleanup (D-A), operating 29 pct of the time, contributes 8 pct to the total; the tail-to-head shearer cut (C-B), operating 71 pct of the time, contributes 63 pct to the total; and the head-to-tail shearer cleanup (E-D), operating 29 pct of the time, contributes 5 pct to the total.

TABLE 4. - Dust source data for Mine 4

Sampling location <sup>1</sup> .....	A	B (cut)	C (cut)	D (cleanup)	E (cleanup)
Sampling time.....min..	51	36	36	15	15
Dust concentration....mg/m <sup>3</sup> ..	0.6	1.2	4.7	1.6	2.2
Dust source.....	A	B-A	D-A	C-B	E-D
Description.....	Section intake.	Stage loader-conveyor (cut).	Stage loader-conveyor (cleanup).	Shearer (cut).	Shearer (cleanup).
Dust source concentration mg/m <sup>3</sup> ..	0.6	0.6	1.0	3.5	0.6
Time fraction of mining cycle.....pct..	100	71	29	71	29
Average source contribution mg/m <sup>3</sup> ..	0.6	0.4	0.3	2.5	0.2
Percent of total source contribution <sup>2</sup> .....	15	10	8	63	5

<sup>1</sup>See figure 3.

<sup>2</sup>Total source contribution, 4.0 mg/m<sup>3</sup>; this represents average exposure during cutting and not exposure for compliance purposes.

Since the support movement is on the return air side of the shearer, it does not contribute to the shearer operator's exposure and is, therefore, not being measured. However, although there is no roof support dust measurement, there is an additional stage loader-conveyor dust measurement.

Although the majority of the dust (63 pct) is from the headgate drum (intake air side of shearer) on the tail-to-head cut, this mine was regularly in compliance.

Mine 5--Unidirectional Head-to-Tail  
Cutting Sequence With Support  
Movement on Shearer Intake

Mine 5 has roof support movement on the intake air side of the shearer during the head-to-tail cut.

Results of the sampling analysis are shown in table 5. According to table 5, the section intake (A) contributes 5 pct to the total source contribution

100 pct of the time; the stage loader-conveyor (B-A), operating 100 pct of the time, contributes 58 pct to the total; roof support movement (D-B), operating 56 pct of the time, contributes 30 pct to the total; the head-to-tail shearer cut (E-D), operating 56 pct of the time, contributes 0 pct to the total; and the tail-to-head shearer cleanup (C-B), operating 44 pct of the time, contributes 7 pct to the total.

TABLE 5. - Dust source data for Mine 5

Sampling location <sup>1</sup> .....	A	B (cleanup)	C (cleanup)	D (cut)	E (cut)
Sampling time.....min..	41	18	18	23	23
Dust concentration.....mg/m <sup>3</sup> ..	0.3	3.6	4.5	6.6	6.4
Dust source.....	A	B-A	D-B	E-D	C-B
Description.....	Section intake.	Stage loader-conveyor.	Support movement.	Shearer (cut).	Shearer (cleanup).
Dust source concentration mg/m <sup>3</sup> ..	0.3	3.3	3.0	20.0	0.9
Time fraction of mining cycle pct..	100	100	56	56	44
Average source contribution mg/m <sup>3</sup> ..	0.3	3.3	1.7	0.0	0.4
Percent of total source contribution <sup>3</sup> .....	5	58	30	0	7

<sup>1</sup>See figure 3.

<sup>2</sup>Quantity (E-D) is actually negative: see Appendix C explanation.

<sup>3</sup>Total source contribution, 5.7 mg/m<sup>3</sup>; this represents average exposure during cutting and not exposure for compliance purposes.

This mine was regularly out of compliance. It is obvious that the two largest dust sources for this operation are the stage loader-conveyor (58 pct) and the roof support movement (30 pct). Referring to table B-1, it can be seen that both stage loader-conveyor dust and roof support dust contributions fall outside the range for the longwalls in compliance. Note that the stage loader-conveyor dust is on the intake air side of the roof support movement and therefore is a major contributor to the support operator's as well as the shearer operator's exposure.

The reason that the shearer operator exposure is so low is that the shearer was equipped with the Bureau-developed "shearer-clearer".<sup>8</sup> However, this device did not help the mine achieve compliance because the shearer was not the main source of dust, which can easily be seen from the data.

<sup>8</sup>Kissell, F. N., N. Jayaraman, C. Taylor, and R. Jankowski. Reducing Dust at Longwall Shearers by Confining the Dust Cloud to the Face. BuMines TPR 111, 1981, 21 pp.

## SUMMARY

This report has shown:

1. How to evaluate the dust sources on your double-drum shearer longwall operation, regardless of cutting sequence, and
2. How your results compare with the cleanest double-drum shearer longwall operations.

Since it is recognized that all operations are different in some respect from each other, this paper has attempted to present enough examples to cover a

variety of circumstances. Once the analysis has been performed and the major dust source(s) identified, the effectiveness of any subsequent dust control technique can be evaluated simply by repeating the test program and comparing the results. The quantities to compare are the total source contributions in milligrams per cubic meter before and after implementing a dust control technique. These quantities estimate the total shearer operator dust exposure during actual cutting of the coal.

## APPENDIX A.--SAMPLING SEQUENCE

As an example, a step-by-step sampling sequence is provided. It will be assumed for the example that a unidirectional head-to-tail cutting sequence (this sampling strategy will apply to all cutting sequences) is used and that the sampling locations are those as described in figure 3.

1. A sampler package (stationary) is located at A to measure the section intake dust concentration. It is turned on just prior to testing.

2. One individual stands 15 to 20 ft on the intake air side (D) of the shearer, and the other stands at the shearer midpoint (E), between the operators. They will collect mobile samples.

3. Once the shearer has fully sumped into the face and cleared the headgate, the sampling pumps are turned on (note sampler start time).

4. Before the shearer reaches the tailgate, the sampling pumps are turned off (note sampler stop time).

5. This set of filters (set 1) is changed and replaced with a different set (set 2).

6. The survey team assume their same positions (B, C) for the tail-to-head cleanup pass.

7. Once the shearer has begun the tail-to-head cleanup and has cleared the tailgate, the sampling pumps (set No. 2) are turned on (note sampler start time).

8. Before the shearer reaches the headgate, the sampling pumps are turned off (note the sampler stop time). This sequence can be repeated over and over again by simply using filter set 1 and the head-to-tail pass and filter set 2 on the tail-to-head pass.

9. When testing is finished, sampler package A is turned off.

Some general instructions and comments concerning sampling should be made.

a. The mobile samplers (B, C, D, and E) should not be turned on until the shearer is fully sumped into the face.

b. The mobile samplers (B, C, D, and E) should be turned off just before the shearer completes the pass.

The important point to be made in items 1 and 2 above is that the sampling should not include phases that are short pieces of the cutting sequence; that is, breaking out into the headgate or tailgate, or wedge cutting at the snake. There may be minor contributions to the total dust exposure of the shearer operator, and inclusion would complicate the analysis.

c. All sampler filters (except sampler A) must be changed after the samplers are turned off at the end of each pass. These will be used over again for each successive and *identical* pass. Filter changes can be performed in two ways. First, the filters themselves can be changed. Second, duplicate sampling packages (or vests) can be used and switched after each pass.

d. All start-stop times of the samplers (including sampler A) must be recorded. One convenient method of recording times is to use a small, permissible, minicassette voice recorder.

e. It is necessary that a minimum of 0.2 mg of dust be deposited on each filter to provide accurate weighing of the filters (see appendix C).

f. Two days of sampling are recommended.

g. Sampler package A must be located in the primary intake airway (last open crosscut). Since its function is only to provide an estimate of the dust entering the section during the testing, package A can be left turned on during the entire testing program.

h. The survey team members follow the shearer, maintaining their positions with respect to the shearer (B and C on the tail-to-head pass, D and E on the head-to-tail pass). See figure 3.

APPENDIX B.--SHEARER OPERATOR DUST SOURCE CONTRIBUTIONS  
FOR SHEARERS IN COMPLIANCE

After dust source contributions are determined, it is important to know how each source compares with longwall double-drum shearers that are regularly in compliance.<sup>1</sup> Table B-1 presents two quantities for each major dust source: (1) the range of dust concentrations, and (2) the percentage range of each dust source's contribution for the six

longwalls in a recent Bureau survey of longwalls regularly in compliance. It is important to emphasize that the dust concentrations in table B-1 for the dust sources are those only during the actual cutting and cleanup operations and not an 8-hr time-weighted average. As such, they can in no way be used for compliance purposes.

TABLE B-1. - Typical longwall<sup>1</sup> double-drum shearer dust source contributions obtained from a survey of six longwalls regularly in compliance

Dust source	Range of average source contributions during cutting, mg/m <sup>3</sup>	Range, pct of total contribution
Section intake.....	20.2-0.8 <sup>3</sup>	9-18
Stage loader-conveyor:		
Cutting.....	.3- .8	7-19
Cleanup.....	.1-1.0	5-20
Support movement.....	.0- .3	0- 7
Shearer:		
Head-to-tail cut.....	.1-2.0	4-45
Tail-to-head cut.....	.9-2.5	20-63
Head-to-tail cleanup.....	.2-2.5	5-54
Tail-to-head cleanup.....	.7-1.0	16-45

<sup>1</sup>The values in table B-1 were obtained from longwalls in which the airflow was from headgate to tailgate.

<sup>2</sup>If an MRE equivalent is desired, multiply all concentrations throughout this paper by 1.38. This is unnecessary for the work proposed, however.

<sup>3</sup>One longwall was in compliance with a section intake of 1.4 mg/m<sup>3</sup>. This value was omitted because it is not believed to be representative of longwalls in compliance.

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<sup>1</sup>Taylor, C. D., and R. A. Jankowski. How the Six Cleanest U.S. Longwalls Stay in Compliance. Pres. at the First Mine Ventilation Symp., Tuscaloosa, Ala., Univ. Alabama, Mar. 29-31, 1982; Min. Cong. J., v. 68, No. 5, May 1982, pp. 37-40.

## APPENDIX C.--FILTER WEIGHTS AND ERROR CONSIDERATIONS

It was stated in appendix A, part e, that it is necessary that a minimum of 0.2 mg of dust be deposited on each filter to provide accurate weighing of the filters. There are two reasons for this. First, the standard preweighed filter cassettes are preweighed to only one decimal place, and low dust weights may produce unreasonable weighing errors. Second, the balances used by mine operators may not be capable of accurately weighing filters with less than 0.2 mg of dust. Generally, obtaining 0.2 mg or more of dust can be accomplished by using the same filters over and over again so that each filter represents four passes or more.

The use of a more accurate balance will allow the mine operator to collect less dust on the filters.

It is important to state that the data presented in this paper were based on dust masses less than 0.2 mg. Although the filter cassettes used were preweighed to the nearest tenth of a milligram, they were reweighed before and after use to the nearest thousandth of a milligram.

If the operator wishes to collect less than 0.2 mg of dust, as the Bureau did, high accuracy balances are available from

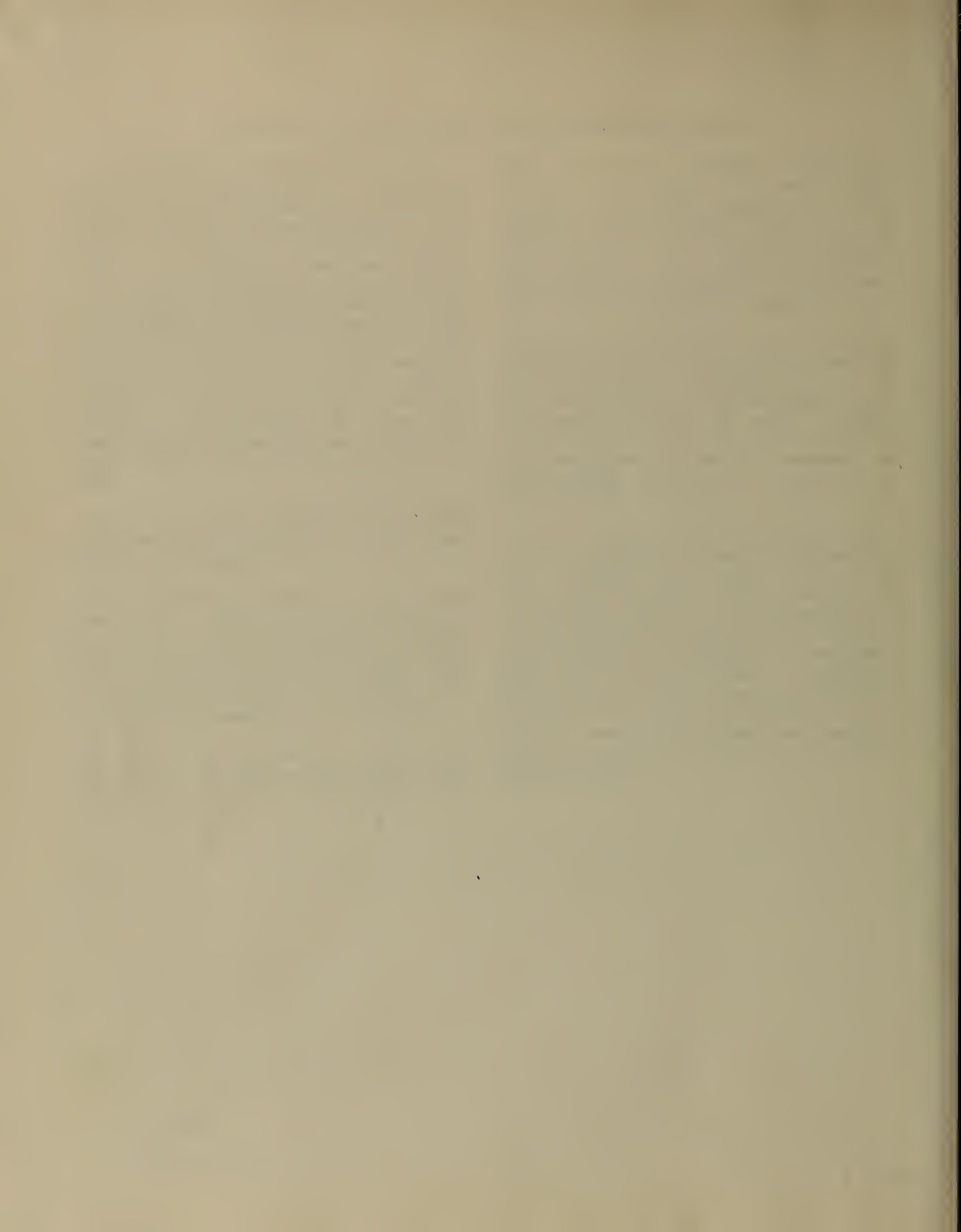
MSHA. The Code of Federal Regulations (30 CFR, Part 70.209 D) permits mine operators to collect samples for test purposes, and the mine operators can request MSHA to preweigh and postweigh the filters to the desired precision, thus reducing the amount of dust necessary for accurate filter weights.

Considering the generally small amounts of dust collected on each filter that can produce significant weighing errors, it is recommended that sampling pumps of the flow-regulating type be used, although non-flow-regulating pumps are acceptable. The former type of pump is recommended so that sampling error due to pump airflow variations is minimized.

In the sampling analysis examples presented, certain dust source contributions (for example, E-D) are listed as 0.0 mg/m<sup>3</sup>, although the calculated value was slightly negative. This result can be attributed to sampling errors such as pump variation and weighing errors. However, the important result is that the dust source was not a major contributor to the shearer operator's exposure. If it had been, the calculated quantity would have been positive, regardless of sampling error.

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